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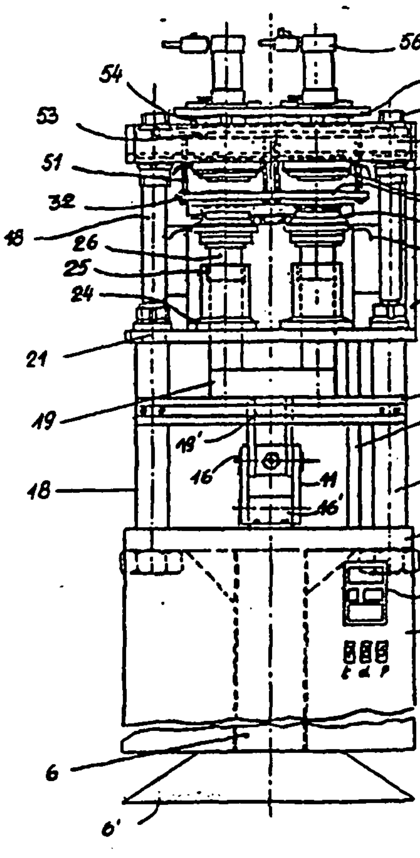
(54) Title: IMPROVED APPARATUS FOR GRANULAR CRACKER PRODUCTION

(57) Abstract

In a cracker production apparatus of the type comprising a heatable mould consisting of a stationary upper mould element (7), a movable ring mould (10) and a reciprocating lower mould element or punch (9) driven by a hydraulically actuated toggle-mechanism (11), the improvement wherein a twin-head mould arrangement for high rate, automatic manufacture of uniformly expanded crackers is driven by a single hydraulic drive unit formed of two aligned, cooperating double-action pistons, whereby a first piston is adapted to control, in combination with specific central program/microprocessing means, an adjustable final baking pressure, and a second piston to regulate a desired expanded cracker thickness, and this independent of grain feed and/or apparatus related mechanical parameters. Advantageously two twin-head machines are arranged in tandem with a single hydraulic drive unit and mutually connected toggle members. The ring moulds may be designed for allowing multiple cracker production in each mould set.



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IMPROVED APPARATUS FOR GRANULAR CRACKER PRODUCTION

The present invention pertains to the field of manufacturing granular crackers by a direct pressure-baking process whereby cereals such as rice, corn, wheat, barley, oats and the like granular raw materials, including soya beans and/or other desirable additions, are subjected to baking or roasting under high crushing pressure in a heated mould and thereafter caused to expand in the form of a selfsustaining cracker, cake, waffle, slice or any suitable shape and thickness. More in particular the invention relates to an improved apparatus for automatically preparing such granular food products under better controlled conditions of pressure-baking and subsequent expansion. This invention especially relates to an improved apparatus having a greatly increased cracker production capacity.

An equipment for such cracker manufacture is notably described in the Belgian Patent BE-A-1000311 and in the International Patent Application WO88/06425 (EP-A-0359740), which are both assigned to the same inventor as of the present invention.

The basic components of the equipment disclosed in said documents is incorporated herein by reference and also as starting point of the present invention.

In BE-A-1000311, and partly WO88/06425, the previous machine improvements proposed by the present inventor mainly concerned the provision of a unique hydraulic drive and control unit formed of two aligned double-

action cylinders, integrally assembled in a drive block for controllably powering and displacing the main drive shaft thereof. Said driven shaft actuates a toggle-mechanism that is connected to a lower die or punch for slidingly reciprocating the same in and out of a mould cavity defined in a fixed upper mould. An adjustable micro-switch contact provided between the upper toggle arm and a switch support on the machine frame controlls the end of compression stroke of one of the operating pistons, whereby the uppermost position of the punch during crushing/compressing the grain material in the mould cavity is attained. Said arrangement enables a reliably smooth running of the machine and the obtainment of uniformly expanded crackers of constant thickness.

In WO88/06425 there is further disclosed a unique three-part mould configuration, wherein a separately actuated peripheral mould element fulfills the function of a movable peripheral side-wall of an otherwise fixed upper mould. Said peripheral or ring mould is capable of being tightly pressed against a fixed upper heatable mould and of slidably receiving a lower heatable punch for crushing and pressure-baking a given quantity of granular material in the hermetically closed, heated chamber formed by the three cooperating mould elements. After pressure-baking and partial redrawal of the punch for allowing a sudden expansion of the heated crushed grains in a still closed mould cavity, the ring mould is moved downwards and th punch is lowered to such an extent that the obtained cracker resting on the punch head can be discharged therefrom by a pushing element of the grain feeding slide entering the space between the upper and lower/periph ral mould elements. Said arrangement has the important advantage of reliably solving the problem of mould sticking, which was her to a major cause of inferior cracker

quality, mould contamination and frequent machine downtime. Notwithstanding the thus achieved important improvements, there was still a need for further technical progress in automatic equipment for mass production of granular crackers, particularly a better control of baking pressure and expansion conditions - especially at high-rate production - and this in the presence of unavoidable variations in grain feed and cereal type parameters. Furthermore there was a real need for increasing the production capacity of a given machine unit, bearing in mind that an advanced hydraulic drive and control block is an expensive piece of technology.

Concerning the remaining problems felt in respect of insufficiently consistent pressuring and expansion, these were thougt to be related to a less adequate design of the hydraulic drive cylinders and of the means used for regulating the end point of the compressive stroke of the final drive cylinder, which in fact controlls the punch pressure in its uppermost pressing position. In this connection it was experienced that the previously used microswitch end position control means often gave rise to too large a variation in baking pressure, resulting in inconsistent cracker quality. This was assumed to be affected by uncontrollable mechanical (elastic strain) effects associated with the machine frame and the toggle-mechanism stiffness, and further by variations in grain supply (granulate size, volume, weight) and grain material type which have an influence on the grain crushing "strenght - strain" curve and hence on attainable pressure in the mould for a predetermined position of the microswitch end control means.

Concerning the need for a greatly increased cracker-production capacity for a given machine, this may in theory be fulfilled in different ways. First there is a possibility of increasing the machine drive speed, but this is of no big use given the inherent limited velocity of a hydraulic drive system. Furthermore the shortening of the baking-cycle is restricted since a shorter baking time cannot be compensated - for respons of cracker quality - in a proportional way by raising the baking temperature, leading to increased risk of burning and mould contamination.

Secondly, there is the possibility of conceiving a multiple-cracker mould, but this requires a complex multi-chamber die design and/or an accordingly complex and heavier punch construction. Moreover, the supply of correct quantities of granular raw material to a " multiple head " punch becomes increasingly difficult or even impossible without spilling and mould contamination.

Another multi-cracker production alternative is the arrangement of a series of moulds in a " multi-head " machine, as already suggested in WO88/06425. However, the provision of plural moulds to be actuated simultaneously by a single drive and control unit appeared to create severe problems in machine stability and in dimensional matching of the cooperating mould elements.

Moreover, it posed insurmountable difficulties in respect of compensating local mechanical distortions and/or differential dilatation/contraction effects between the plural mould sets, which have to be guided correctly at the same time in an accurate fitting way. This was critically important for three-part moulds having a movable peripheral ring element.

In this respect the present inventor carried out extensive investigations on the design and workability of multihead machines comprising more than 2 three-part mould sets driven by a single hydraulic unit. He found out however, that this high-production machine concept was not reliable in practice,in spite of all trials and mechanical measures for stabilization and mould guiding improvement.

The present invention has for its general object to provide a cracker production equipment which solves the above mentioned control and capacity problems in a very efficient way. A particular object of this invention is to provide a compact high-capacity apparatus for preparing expanded grain crackers featuring one hydraulic drive and control system of improved concept and capable of accurately driving two three-part mould sets, which arrangement surprisingly appeared to give excellent results.

According to the invention, these and other objects have been achieved by an apparatus as defined in claim 1.

Advantageous and preferred embodiments of the invention are defined in the appended subclaims.

Other details and features of the invention will stand out from the following description, given herebelow by way of non-limitative example and with reference to th accompanying drawings, wherein

Figure 1 gives a side view of a preferred twin-head apparatus embodiment according to the invention

Figure 2 is a front view of the apparatus shown in figure 1

Figure 3 gives a schematic view of improved drive and control means according to the invention

Figure 4 is a lenghtwise cross-section of a preferred embodiment of a hydraulic drive block

Figure 5 shows more into detail a three-part mold used in the inventive apparatus depicted in figures

Figures 6 a-b-c illustrate ring mould designs for producing multiple crackers in one mould set

Figure 7 schematizes a component of the central control means

Figures 8 a-b show a tandem machine arrangement having a single hydraulic drive for two twin-head machines

Referring to figures 1 and 2 , there is shown a preferred embodiment of a high-capacity cracker production apparatus according to this invention, which basically features a twin-head arrangement of two three-part moulds with one drive unit comprised of an improved hydraulic drive and control unit and a two-arm toggle mechanism for the controlled and simultaneous actuation of the reciprocatable lower mould elements (punches).

This apparatus features a compact and most effici nt design of all the basic machine parts and functions arranged on a selfsustaining frame and displaceable therewith.

The main machine components comprise moulding means (1), feeding means (2), hydraulic driving means (3), hydraulic

power means (4) and central command, control and monitor means (5) which are assembled onto a columnar machine frame comprised of two vertical posts (18) which are mounted on base support (6) with base plate (6').

Two three-part mould sets (1) are disposed side by side between supporting columns (18) and consist each of a fixed upper mould element (7), a driven lower mould element or punch (9) and a movable peripheral mould element or ring mould (10) which cooperate to define a compressable, heatable mould cavity therein. Upper and lower mould elements (7,9) are separately heated and temperature controlled allowing independant adjustment of required temperatures in both upper and lower mould elements of each mould set. A fixed upper mould plate (8) connecting the vertical posts (18) bears the fixed upper moulds (7) at the underside thereof. Said mould plate (8) is adjustable in height by suitable fastening elements (8') at the upper part of the columnar posts (18). This height regulation allows to precisely adapt the fixed position of the upper moulds (7) in relation to a required preset top position of the punches (9) corresponding to a safe uppermost position of the raised toggle-mechanism (11), and further to adjust parallellism betwe n upper and lower mould surfaces.
The ring moulds (10) are fixed to and actuated from above the mould plate (8), as will be described into more detail hereinbelow with reference to figure 5.

The two punches (9) are driven up and down by drive means (3) consisting of a hydraulic drive unit (12) with two cooperating pistons (13,14) actuating a drive shaft (15) and of a toggle-arm mechanism (11) having a central hinge block (16) connected to drive shaft (15).

The two punches (9) have parallel shaft members (26) slidably guided in bearing bushes (25) which have cylindrical housings (24) mounted on a horizontal support plate (21) which is fixedly connected to frame posts (18).

Between mould plate (7) and support plate (21) there are erected preferably 4 regulable stiffening rods (23) which connect the 4 corners of the respective underside and upperside of mould plate (7) and support plate (21). In this way the cooperating guiding parts of the mould elements are adjustably secured against possible mismatch or distortion during running of the machine.

Similar stiffening bars (23') may be provided between support plates (21) and (22), although it is more preferred here to select a distortion-proof heavy column design.
The lower ends of punch shafts (26) are mounted on a horizontal cross-bar (19) which forms at its lower part a movable hinged connection (19') with the upper arm of the toggle-mechanism (11).

In this way the two punches are simultaneously driven up and down.The lower arm of the toggle-mechanism rotates around a fixed hinged connection (16') solidary with upper support plate (22) of frame support (6). A security stop plate (20) horizontally mounted between machine posts (18) prevents that toggle-mechanism (11) is pushed over its dead point or vertically erected position (180 degrees for max.angle formed by toggle-arms).

In pratice the angle between erected upper and lower toggle arms is adjusted to a maximum value of about 170 to 178 degrees, which corresponds to the uppermost posi-

tion of the punch touching then the fixed upper mould (8) (without grain feed). Said value can be preset by means of adjustable mould plate (7) in conjunction with a given dimensional design of drive unit, drive shaft and toggl mechanism. Drive unit (3,12) is mounted in a side frame (27) affixed to bearing plates (21) and (22) of the main frame, located above hydraulic power group (4). The back side of the drive unit is prolonged with a shaft (29) which forms a fixed hinge connection (28) with side frame (27). The hydraulic power group (4) mounted on base plat (6') basically comprises a hydraulic container (30) with motor (31). Pressure-control gauge (32) monitors hudraulic pressure and may comprise overpressure limiting means. Alternatively overpressure may be controlled by power-overload limiting means associated with motor (31). Suitable hydraulic valves and tubing provided for powering hydraulic cylinder A and B of unit (12) is not shown in the drawing. The central control panel (5) mounted to the lower front side of the machine frame (6) groups all necessary command, switch, control, program and display functions. It comprises a central processing unit loaded with a cracker production program wherein the following adjustable main parameters are integrated : baking time (t), baking pressure (p) and cracker expansion thickness (d). Desired combinations of these parameters can be selected, within predetermined (program) limits, by suitable positions of their respective command knobs or buttons. Furthermore the processing unit controls the required actuation sequence of the cooperating hydraulic pistons (13,14) and the command sequence of the pneumatic cylinders (42,43,56) actuating the feed means (2) and the ring mold elements (10).

The central control panel also comprises a separate processing unit for controlling upper and lower mold temperatures of the two-mould sets and for accordingly

supplying electric power to the resistance heating elements (35) mounted in the interior of upper mould el - ments (7) and the punch heads (9). Thermocouple means (not shown) conveniently integrated in each of said mould elements give a direct reed-out (displayed on control panel) of instant upper and lower mould temperatures, and there electric signal is directly converted, by the intermediate of a special "self-tuning" program running on said processing unit, in an adjustable supply of electric power to the resistance heaters of the respective mould elements, depending on preset mould temperature, ambient thermal conditions and instantaneous cracker production conditions (weight, thickness, production rate...).

In this way mould temperatures can be kept within about +/-1 degree Celsius of preset temperature, notwithstanding fluctuating production circumstances.

Feeding means (1) include i.a. a feeding plate 60 with dosimeter slides and pneumatic cylinders 62 and 63,63' for actuating said plate and slides. Reference numeral 61 is a grain supply tube).

The novel means for ensuring a precise control of cracker production in terms of ultimate baking pressure (Pu) and expanded cracker thickness (d) according to the present invention are greatly improved over previous control means in that they are no longer sensitive to normal variations in grain feed parameters and to certain mechanical limitations of the used drive and transmission members, which otherwise affected the final crushing/compressing stroke and further the thickness and surface shape/structure of a finished cracker.

Said novel means comprise the combination of a redisigned hydraulic drive unit and of specific hydraulic power control means steered from the central control panel.

The improved hydraulic drive and control unit is illustrated in figures 3 and 4. Referring to figure 3, schematizing a hydraulic drive block 12, it is shown that two double action cylinders A and B are aligned and fitted in a traction frame comprising 4 traction bars 40 and end flanges 41,42,43 and 44 with adjacent flanges 42,43 forming the block separation mid flange. Reference 45 represents the adjustable magnetic contacts M1 to M4; these are slidably located in predetermined positions which define the basic displacement regions or stroke lengths of the hydraulic pistons, actuated in a given sequence by the central control unit 5. The left cylinder A, driving shaft 15 connected to the toggle-mechanism, is adapted to function as baking pressure controlling means.

The right cylinder B is adapted to function as expansion controlling means. Magnetic contacts M1 and M3 placed in positions A1 and B1 close to mid flange 17 define the retracted position of piston 13 of cylinder A and of piston 14 of cylinder B. When both pistons are withdrawn into A1 and B1, the mould is fully open with the punch in a lowermost position below to feeding slide (alarm or servicing position when machine is stopped). Contact M2 placed in A2 (with M3 in B1) defines the operating start or end position of the punch corresponding to grain feeding/cracker ejection. Contact M2 placed in B2 sets a given stoke lenght B1-B2 of oppositely displaced piston 14 of cylinder B, the amount of which defines the fall back height of the punch in the reverse cycle B2-B1 of piston 14 of cylinder B.

Hence B1, located close to mid flange 17, also define therein a stable fall back position for the punch upon explosive expansion of the crushed pressure-roasted grains. In a cracker production cycle, piston 13 is first

moved to its operating start position A2 and therafter piston 14 is displaced from B1 to B2. At this point piston 13 will commence its compression stroke from A2 to A3. Said stroke includes the last grain crushing upward movement of the punch and the ultimate baking pressure build-up in the mould. In earlier apparatus designs, the end of the compression stroke was controlled by an end switch element, e.g. a contact placed in a position A3 and/or by an adjustable microswitch contact elements working between a toggle arm and a fixed frame member. These adjustable contact means besically function on approaching distance, which seems precise enough for uniform constant conditions of grain feed and constant stiffness/elasticity of structural members. However, even in such circumstances the actual maximum pressure build-up in the baking mould could still considerably fluctuate given the disproportionately large effect of small distortions (tenths of micrometers) and of inhomogeneous grain distribution on the accuracy of the uppermost punch position and final pressure.

According to the invention the end point A3 is not a fixed position preset by distance switch means, but is defiend as a slightly variable point of a small region A3A'3 which is controlled by an adjustable short (extra-)time duration during which a hydraulic valve is kept open. Indeed, the last fraction A'3A3 of the total displacement time needed for stroke length A2-A3 corresponds to only a negligible displacement of the punch. Controlling said time fraction (tenths of a second) from the central control panel, empirically correlated to grain feed parameters (pressure-time correlation equation), provides a surprisingly effective and simple means for establishing consistent pressure-baking conditions, and

hence uniform starting pressures for th consequ nt explosive grain expansion.
On the other hand the finished cracker thickness and surface structure is regulated by a second timing means which actuates piston 14 for a preset time from its fallen back position B1 to a regulable position B3 between B1 and B2.
Thus, a complete cracker production cycle is composed of the following actuating sequence and positions of the pistons 13 and 14 : (A1-A2 start) B1--B2, A2--A3, B2--B1, B1--B3--B1, A3--A2.

Figure 4 gives a more detailed view of a preferred design embodiment of a hydraulic drive unit used in an apparatus according to the invention. The hydraulic block 12 comprises two cylinders (71,72) with front and back flange (73,74) and a mid flange 17 fixed together by traction bars 40. The integral mid flange 17 is at the same time back flange of cylinder 71 and front flange of cylinder 72. It is shown that pistons 80 are withdrawn in their rest position close to said mid flange. The pistons actuate drive shafts (15,15') guided through the block flanges by bushings 76 and sealed by end seals (75,76). Reference numeral 45 denotes the screw connections for the hydraulic fluid supply tubes. The pistons are provided with a seal 77 and sliding guides (78,78'), both made from a frictionless material, e.g. PTFE to ensure high displacement speeds.
To increase the reaction velocity of the hydraulic shaft, which is most important at stoke reversal (fall back of punch upon expansion), the sliding resistance at the exits of front and back flanges is diminished by disposing there the combination of a damping ring 81 and s aling ring 82. Preferably the sealing ring is conical,

to cooperate with a conical damping sleeve arranged at the end portion of drive shaft 15 (close to piston).

In this way the sticking and braking of the hydraulic shaft upon numerous reverse displacements (i.e. after full forward stroke and stop) is largely eliminated. Further improvements include the provision of conical damping chambers instead of the conventional damping cylinders in order to achieve a progressive damping at stroke end (mould closure) and at the same time to prevent a brake or friction effect when opening the mould. Said damping chambers are integrated in mid flang 17 and cooperate with a conically designed end portion 79 of the hydraulic shaft of each piston. Numeral 84 and 85 refer to a O-ring and an annular element. In addition air escape means are provided outside said damping chambers. Figure 5 illustrates the construction and arrangement of a three-part mould used in the apparatus of the present invention. Upper mould plate (8) , adjustably fixed to columnar frame posts 18 by regulable nuts 8' bears upper mould 7 fixed thereto by a central mounting element 57. A fixed bridge 55 fixedly erected on mould plate 8 by means of pins 54 supports a pneumatic cylinder element 56 having a actuatable shaft 56' passing through fixed bridge 55. Shaft 56' is connected to a lower movable bridge frame 53 comprising guiding rods 51 slidably passing through corresponding bores in upper mould plate 7. The lower end portions of said guiding bars are connected to side flange elements 52 of ring mould 10. Punch 9 is arranged below upper mould 7. The upper portion of the punch (punch head 9') is adapted to be slidably received within the cavity of ring m uld 10, the latter in its uppermost position, when pressed against upper mould 7 by pneumatic cylinder 56, being sealed by sliding over a corresponding die element 7' of upper mould 7. The

height of the cylindrical upper portion 9′ of punch 9 is at least equal and preferably slightly larger than the thickness of ring mould 10 (e.g. 20 mm versus 18 mm depending on desired cracker thickness).
Advantageous embodiments of said mould configuration comprise multiple-cracker moulds formed of a ring mould as depicted in figure 5 and comprising a plurality of cylindrical mold cavities of any desired shape.

Said cavities slidingly cooperate with a punch having a head 9′ in the form of cylindrical elevations of the same pattern and shape of said ring mold cavities. In the same manner the lower surface of the upper mould is provided with cylindrical die elements of similar shape and pattern, but of smaller height (e.g.4 to 10 mm). It has been found that said covering arrangement of simple cylindrical sliding contacts is surprisingly effective in sealing the mould cavity formed by the 3 cooperating mould elements. Examples are shown in figure 6 a-b for a moon-shaped cracker and in fig. 6 c for bar-shaped crackers. Remark the entirely cylindrical sealing surfaces 9′ and 7′ of upper and fower dies.

In addition to allowing the troublefree production of a plurality of small crackers with one mould set (without sticking), the present mould concept also has the advantage that it can be adapted to produce expanded crackers having a curved upper and lower surface, including comparatively thin crackers (chips).

For this purpose only the compressing surfaces of upper and lower mould elevations have to be designed as matching concave and convex surface, wherely the ring mould remains unchanged, except possible adaptation of ring

thickness depending on degree of curvature and thickness of the expanded cracker.

To improve the anti-sticking property of the three-part moulds, it is advantageous to apply a thin anti-sticking coating onto their contacting surfaces. Preferably a coating essentially comprised of TIN (titanicum nitride), including TiC, TiO and nitrides carbides, carbonitrides of other desirable metals, is used. Said coating can be obtained by sputtering, ionplating, plasma CVD and similar high-tech deposition processes.

Figures 2 (lower part) and figure 7 schematize an example of a cantral command and control cabinet (5). As can be seen from figure 7, the adjustable parameters baking pressure (P), baking time (t) and crackers thickness (d) are digitally fed to a programmed microprocessing unit of the control system, which centralises commands and controls all the operational functions of the machine (drive means, feeding means, actuation means for ring mould, etc..). The mould temperature (T) is monitored, controlled and adapted by a seperate processing unit. In a twin-head machine there are four mould elements equipped with resistance heaters disposed below the compressing surfaces of respectively upper moulds and punches which are of a layered design.

Each moulding surface is provided with a thermocouple fitted in a radial bore extending clos to the central fixation m ans of said layered moulding elements. This enables a very accurate, instantaneous control of mould

temperature, whereby deviation from a desired baking temperature (conveniently from about 280 degrees Celsius to 320 degrees Celsius) is kept within close tolerances of about max. 1 degree Celsius. This operational uniformity is achievable in fluctuating production conditions (ambient temperature, production rate, cracker weight/thickness) thanks to the self-tuning property of the programmed temperature control and processing unit.

An advantageous embodiment of the present invention is illustrated in figures 8 a-b. Accordingly two apparatuses A and B, in this case twin-head machines equipped with ring moulds is shown in fig. 8 a, are arranged in tandem at opposite sides of a central cracker discharge and conveying means (101) passing between them at the lowery side of cracker discharge chutes (102) of their respective moulds, said conveying means being located above drive means (3,11). A single hydraulic drive unit (3) in accordance with this invention drives the two apparatuses simultaneously, which is achieved by linking the toggle mechanisms (11) of the apparatuses by a linking/transmission member (100). As can be seen from figure 8 b the grain feed and cracker push-off devices (2) are located at opposite sides of apparatuses A and B and of conveying means (101). Such an arrangement and lay-out is particularly advantageous in that it is very compact, room and labour saving and in that it needs only one sophisticated hydraulic drive system with corresponding central control panel for a plurality of cracker production mould sets (2 x 2 in this case), necessitating further only one machine setting/regulation for a quadrupled production. Of course a complete production line will consist of a series of such tandem driven apparatuses enclosing a central cracker discharge and conveyor belt which for-

wards a continuous stream of crackers to a convenient packaging station (not represented in the drawings).

The invention is not limited to the embodiments described and exemplified in the above description and annexed drawings.
Other combinations and adaptations are readily derivable from the present invention which all fall under the scope of protection as defined in the following claims.

CLAIMS

1. High-capacity apparatus for producing granular crackers from cereal raw materials by a process of pressure-baking and expanding a given quantity of said cereal material in a heated mould, the apparatus consisting essentially of a compact columnar frame structure bearing respectively in the upper part thereof moulding means (1) and feeding means (2), in the central part thereof driving and actuation means (3) and in the lower part thereof hydraulic power means (4) and central steering and control means (5), for said moulding, feeding and driving means, said moulding means comprising an upper mould plate (8) affixed to and bridging the upper part of frame columns (18) with two heatable moulds located below said mould plate, each mould being composed of an upper heatable mould element (7) fixed to the underside of said mould plate, a movable ring mould element (10) and a driven lower mould element (9) or punch with the lower said shaft portion of said two punches being fixedly connected to a cross-bar (19), said driving and actuation means being comprised of a toggle-mechanism (11) actuated by a hydraulic drive block (12) whereby an upper toggle-arm is hingedly linked to said cross-bar (19), said hydraulic drive block consisting of two fixedly aligned double-action cylinders A and B actuating a drive shaft (15) connected to said toggle-mechanism, wherein a first hydraulic cylinder A is adapted to drive the punches to their compression stroke with controlled ultimate baking pressure, and wherein a second hydraulic cylinder B is adapted to define a fall back position of the punches, including an amount of expansions, after pressure baking, and further to precisely regulate an expanded cracker thickness, said ultimate baking pressure and said precise

cracker thickness being controlled by separate timing means integrated in the central steering and control means (5), whereby a first timing means controls a pressure build-up duration of the hydraulic piston of cylinder A actuating the punch to its uppermost position in the mould, and whereby a second timing means controls an adjustable back-push amount of the hydraulic piston of cylinder B for actuating the punch up and down from its fallen-back position.

2. Apparatus for producing grain slices, crackers or waffles from substantially granular cereal materials by a controlled process of crushing, pressure-baking and expanding a quantity of said materials in a heated mould, said apparatus featuring a compact assembly of moulding means (1), grain feeding means (2), driving and actuation control means (3), hydraulic power means (4) and central steering/controlling means (5) which means are mounted on a generally L-shaped supporting frame (6); said moulding means comprising a stationary, heatable upper mould element (7) affixed to an adjustable mould bearing plate (8), a movable heatable lower mould element or punch (9) reciprocativyly driven upwards from a bottom feeding position to a top pressing position and then downwards over an intermediate expansion position again to its bottom position, and a slidable peripheral sleeve or ring mould element (10) which is movable between an upper closing position in which it seals the upper mould element and a lower open position in which it is slided over the lowered punch so as to allow cracker discharge and supply of granular material onto the punch, said upper, peripherial and lower mould elements cooperating to define a mould cavity therein for receiving said grain

material to be hot compressed under high pressure subsequently be expanded when the mould is still closed, said driving and actuation control means comprising a two-arm toggle mechanism (11) connected to the punch and a hydraulic drive block (12) formed of two aligned cylinders which are joint back-to-back and have separately actuatable double-action pistons (13,14) for driving a hydraulic drive shaft (15) connected to the toggle-arm hinge (16), <u>characterized in that</u> the drive piston (13) of a first cylinder (A) disposed closest, is adapted to fulfill the function of controlling means for the compression of the granular material and the baking pressure in the mould; whereas the piston (14) of a second hydraulic cylinder (B) is adapted to control the required expansion extent and cracker thickness, whereby each piston basically has 3 specific displacement positions: (I) a first position (A1,B1) in which both pistons are retracted to the starting point of their opposite stroke close to the adjacent facing sides of a mid-flange (17) joining the two hydraulic cylinders, which position defines the lowest possible position of the punch and toggle-arms wherein the then entirely opened mould can be cleaned, (II) a second position (A2) of the first piston laying between its retracted position (A1) and a stroke end position, said adjusted position (A2) corresponding to the lower feeding position of the punch during cracker production, and also a second position (B2) of the oppositely displaced piston (14) of the second cylinder B which defines an adjustable expansion position of the punch in relation to the regulable distance B2-B1, and (III) a dependably controlled third (end)position A3 of the first piston (13) defining and controlling the attainable baking pressure and the end of the pressing/crushing upward movement of th punch during th compression cycle, while a third position B3 of the second piston (14) located between B1 and B2

defines a required constant expansion thickness, the piston displacements to preset positions A1,A2,B1,B2 being permanently controlled in production by th ir associated preset magnetic contacts, while on the contrary the end position A3 of the pressing piston (13) and the intermediate position of piston (14) B3 for the expanded cracker thickness regulation are defined in and controlled from a program running the central steering-/controlling means (5), whereby displacement end point A3 is derived from an adjustable preset time during which a high-pressure valve remains opened for hydraulic pressure build-up in said first cylinder A, and whereby position B3 is determined by an adjustable incremental time for a given back-push length of piston (14) computed following a required final thickness of the produced cracker, said two cooperating pistons (13,14) being controlled from the central steering/controlling means (5) such that they are powered and displaced by hydraulic power means (4) in successive incremental steps through the positions A1 - A2, B1 - B2, A2 - A3, B2 - B1, B1 - B3 - B1, A3 - A2 for performing a cracker production cycle, the first displacement A1 - A2 being effectively needed only when starting from the lowest punch position.

3. Apparatus as defined in claims 1 and 2, wherein said hydraulic cylinders, comprise means to improve the damping property and the reaction velocity thereof, said means including the provision of a conical damping chamber close to the mid-flange (17), preferably common for both cylinders, and of a conical shape of a corresponding end portion of their cooperating hydraulic drive shafts, and further the arrangement of conical s aling rings at an exit port where a hydraulic shaft slides through a front, respectively back flange of the hydraulic block

(13), said rings cooperating with a conical sleeve disposed around a corresponding mid-portion of said hydraulic shaft, said measures being effective in ensuring quick progressive damping of the pistons at the end of their stroke, i.e. when the punch falls back to its expansion position and in enhancing the release velocity of the pistons in the absence of frictional drag or sticking of the hydraulic shaft upon reverse actuation.

4. Apparatus as defined in claims 1 to 3, wherein said central steering/controlling means comprise a first program and microprocessor unit for controlling the process parameters baking time, pressure and expansion and for commanding the actuation means in driving, moulding and feeding, and a second program and microprocessor unit for monitoring, controlling and steering the temperature of and electric power supply to the upper and lower mould elements, said separate control means being adapted for effecting self-tuning regulation of mould temperature with a negligable amount of overshoot or undershoot of about max. 1 degree C.

5. Apparatus as defined in any one of claims 2 to 4 allowing a nearly doubled cracker production for a proportionally smaller increase in energy, operating and installation needs, characterized by a twin-head machine construction comprising the combination of two three-part mould sets arranged side by side between the two main frame posts (18) and of a single hydraulic drive block and toggle mechanism for simultaneously driving the two punches, said three-part moulds having an upper mould element affixed to a common upper mould plate (8) and ring mould elements equipped with separate pneumatic actuation means, moving bar bridges and fixed suspension bridges, and said punches being mounted with a lower

shaft end portion thereof on a horizontal cross-bar below the punch shaft sliding guides, a central block of said cross-bar being hingedly connected to an upper arm of said toggle-mechanism whereby the vertical plane common to the axes of toggle-arms, hydraulic shaft and cylinders is perpendicular to the vertical plane common to the parallel punch shaft axes and cuts the horizontal cross-bar in a point equidistanced from said punch axes, and wherein the feed means preferably comprise a doubled dosimeter-slide with common supporting slide and drive but separate pneumatic actuators for the two dosimeter slide plates.

6. Apparatus as defined in claims 1 or 5, wherein the upper part of the columnar frame comprises a plurality of preferably 4 regulable stiffening bars extending vertically between the upper mould plate a lower horizontal frame plate supporting the punch guides, said stiffening bars being erected in 4 corner portions of said plates and adapted to establish and to maintain correct parallellism between upper, lower and peripheral mould faces, and wherein the lower part of the columnar frame at the level of the toggle-mechanism is protected against buckling and comprises a means for stopping the toggle-arms before their angle reaches or exceeds 180 degrees.

7. Apparatus as defined in claims 1 to 6, characterized in that the three-part mould is designed as a multi-compartment mould for simultaneously preparing at least two crackers with a single mould set which comprises a movable peripheral ring or sleeve of a given thickn ss defined between horizontally parallel, flat upper and lower faces and including at least two cylindrical cavities of a shape and dimension as required by the desired cracker forms and sizes, said peripheral mould

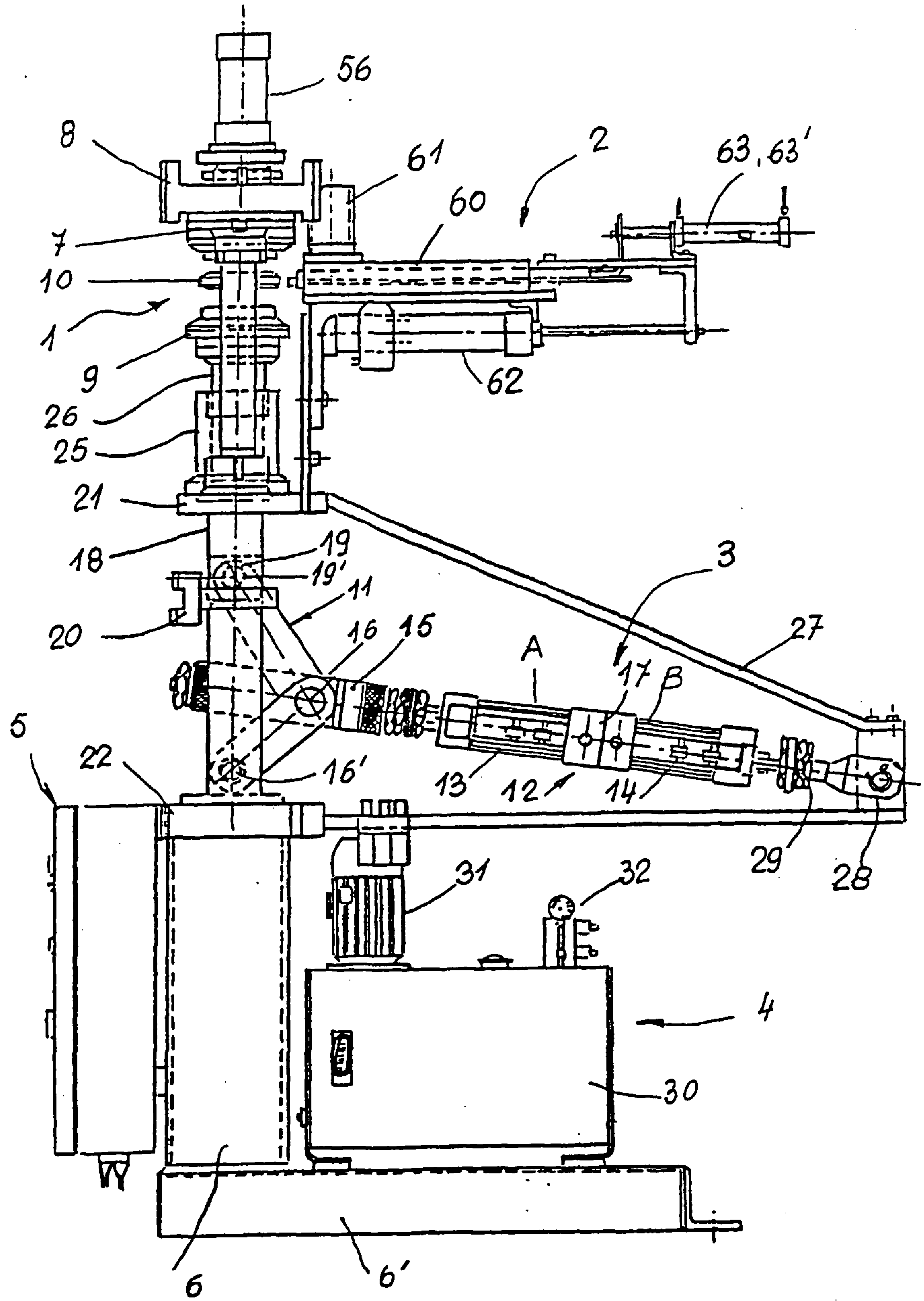
cooperating with a fixed upper mould element formed of flat die portions posessing the same pattern and shape as said cylindrical cavities and extending over a given small distance vertically below a flat upper mould surface such that said die portions seal the upper side of the mould cavities formed therein when the peripheral mould is pressed against the upper mould with the said die portions being slidingly received inside said cavities, and a movable punch having a die surface of the same design as the upper mould but of a height greater than the thickness or depth of said mould cavities, such that the peripheral mould is slidably receivable over a lowered punch below the upper face of said dies, and whereby said peripheral mould element is fixedly suspended to the guiding bars of a movable bridge frame which is actuated from above the upper mould plate by pneumatic means.

8. Apparatus as defined in claims 1 to 7, comprising a three-part mould wherein the upper and lower mould elements have matching pressing surfaces of a curved design, namely a concave upper mould surface and a convex lower mould pressing surface or vice versa, thereby allowing the production of cracker having a bent shape.

9. Apparatus as claimed in any one of claims 1 to 8, wherein the contacting sealing and baking surfaces of upper, peripheral and lower mould elements are coating with heat-resistant anti-sticking layer, which is preferably comprised of Titanium nitride obtained by vacuum plating, ion plating or sputtering.

10. Installation for the continuous production of crackers comprising at least two apparatuses as claimes in any one of claims 1 to 9 and a conveyor means (101) for discharge of produced crackers to a packaging station,

characterized in that said at least two apparatuses are arranged in tandem at opposite sides of said conveyor means (101) passing between cracker discharge chutes (102) of said apparatuses, and in that each tandem arrangement of two apparatuses is simultaneously driven by a single hydraulic drive unit (3) connected to toggle-mechanisms (11) which are linked to each other by a linking member (100).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8
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FIG.1

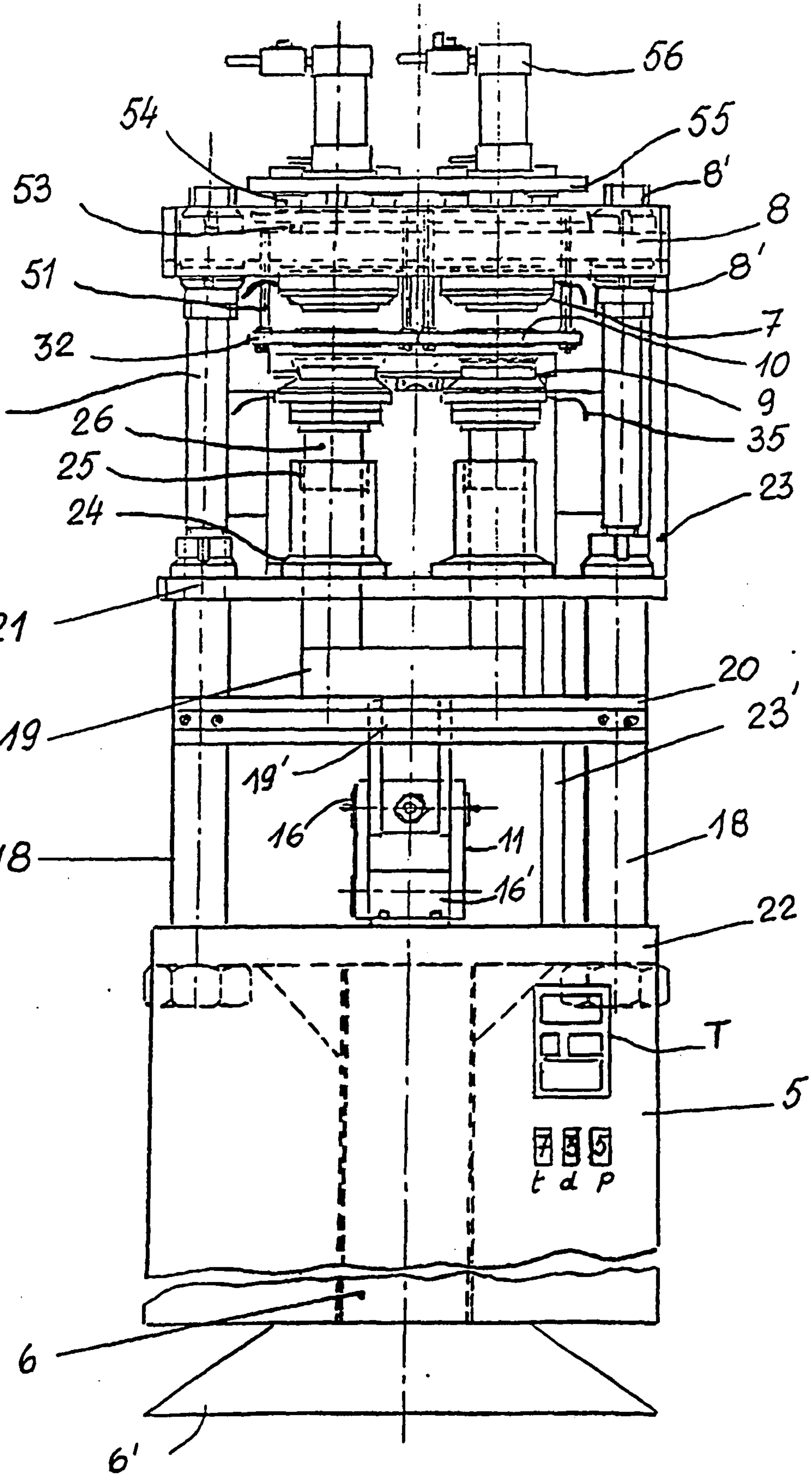
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FIG. 2

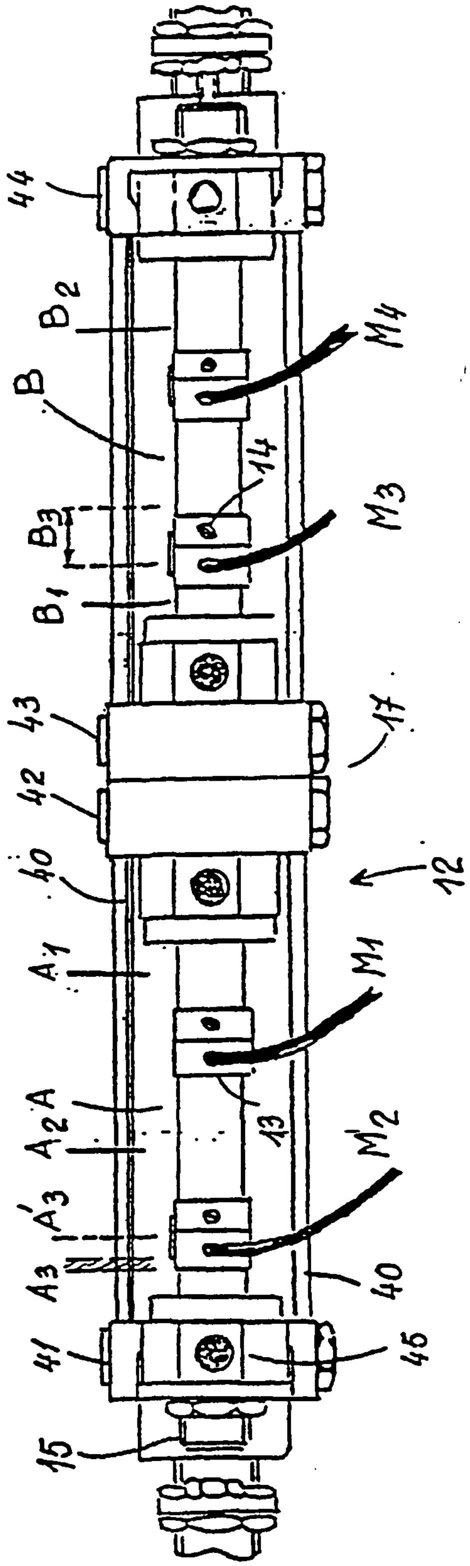

FIG. 3

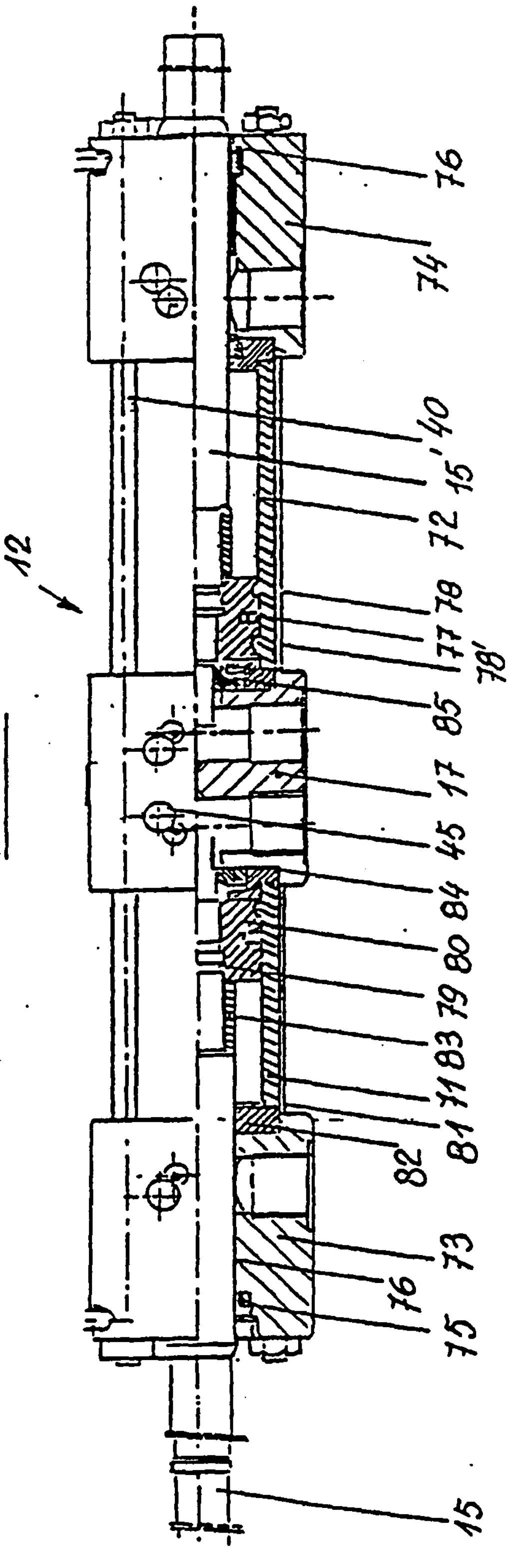

FIG 4

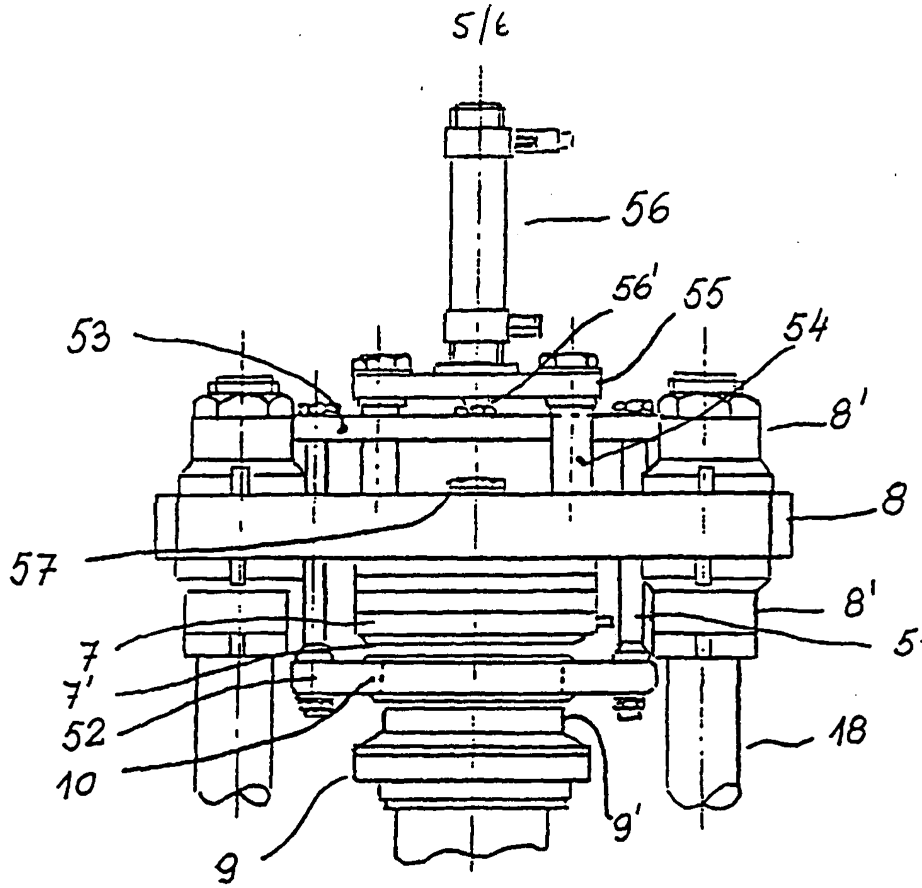
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FIG. 5

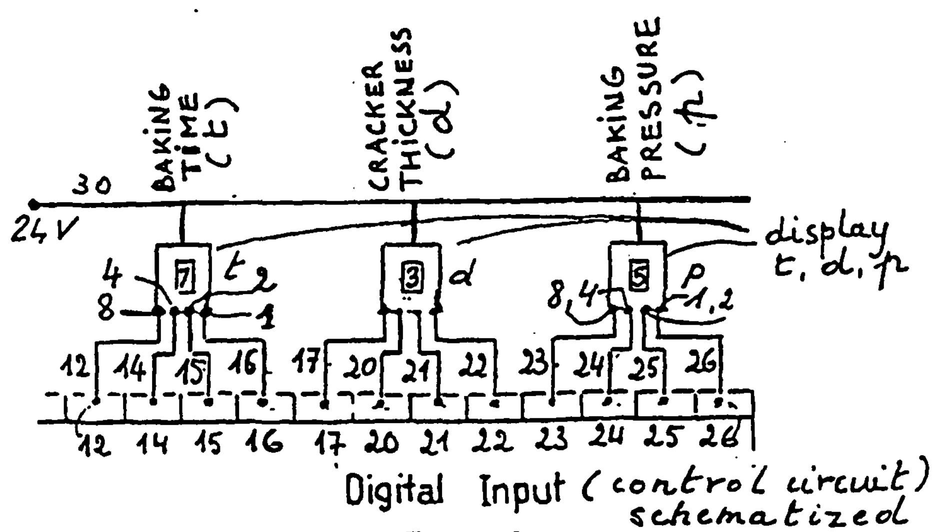

BAKING TIME (t)
CRACKER THICKNESS (d)
BAKING PRESSURE (p)
30
24V
display t, d, p
7
t
3
d
5
p
4
2
8
1
8,4
1,2
12 14 15 16 17 20 21 22 23 24 25 26
Digital Input (control circuit) schematized

FIG. 7

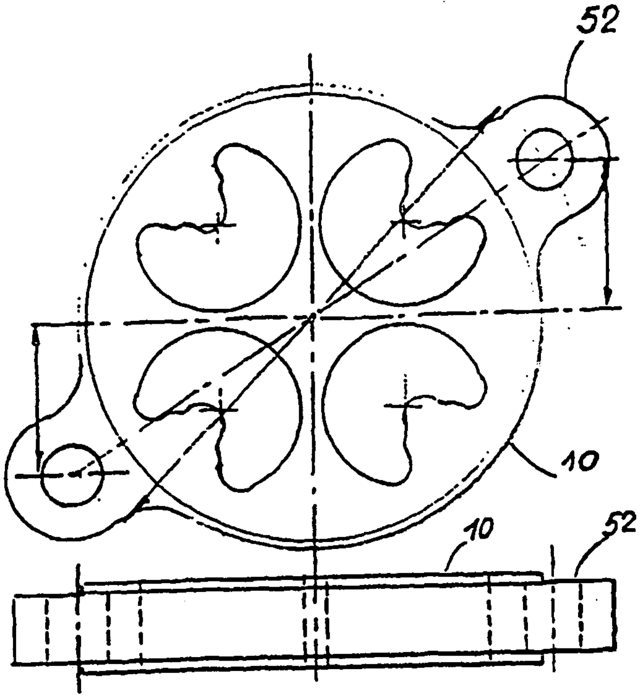


FIG 6.a.

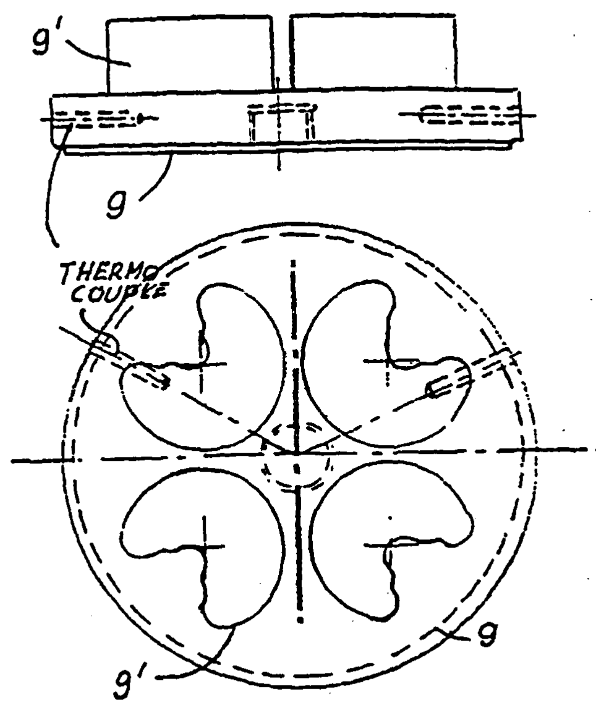
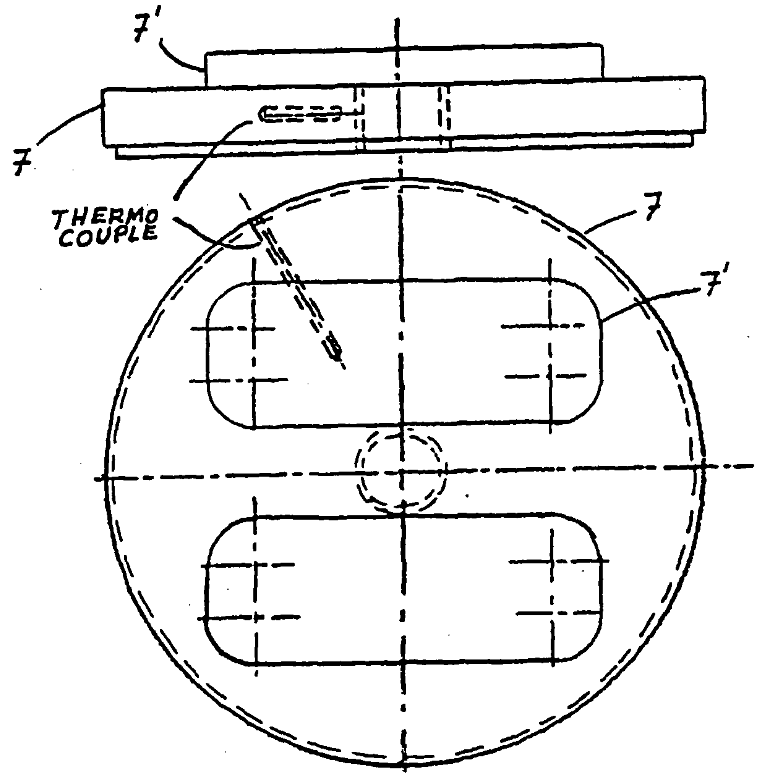


FIG 6.b.

FIG 6.c.



SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No PCT/BE 91/00005

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.5 A 23 L 1/18 A 21 B 5/02

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl.5	A 23 L A 21 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X Y	WO,A,8806425 (R. VAN DEN BERGHE) 7 September 1988, see claims 1,5,6,7,8; figures 1-3; pages 8-9 (cited in the application) ---	1 8,9
A	EP,A,0241972 (O. GEVAERT) 21 October 1987, see column 11; figure 6 ---	1,2
A	EP,A,0344867 (J. VAN WOERDEN) 6 December 1989, see claims 1-7; figures 1-7 ---	2
Y	Derwent File Supplier WPIL, AN = 86-023638(04), 1989, Derwent Publications Ltd, (London, GB), & JP, A, 60244257 (BAIKA KOGYO K.K.) 4 December 1985, see abstract --- -/-	8

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26-09-1991	23-OCT-1991
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	MISS T. TAZELAAR

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	Derwent File Supplier WPIL, AN = 90-161311(21), 1989, Derwent Publication Ltd, (London, GB), & JP, A, 2104496 (KAO CORP.) 17 April 1990, see abstract ---	9
Y	Patent Abstracts of Japan, vol. 14, no. 350, (C-0744), 27 July 1990, & JP, A, 2129035 (OLYMPUS OPTICAL CO. LTD) 17 May 1990, see abstract ---	9
A	FR,A,2617014 (LIMA FRANCE) 30 December 1988, see claims 1-4; figure 1 -----	7